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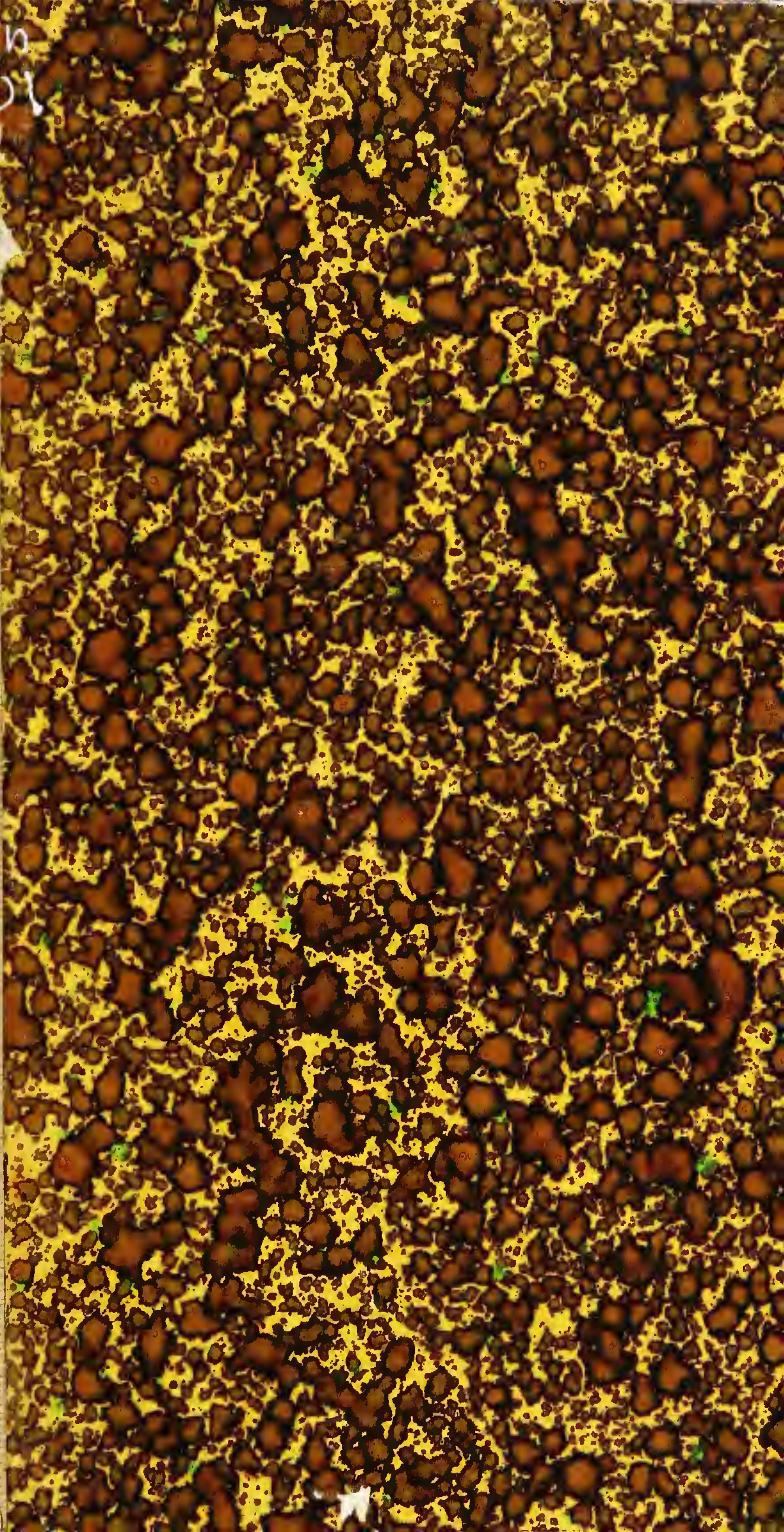

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River, Lake and Land Conservancy in Portions

OF THE

Provinces of Anhui and Kiangsu,

North of the Yangtsze River

Preliminary Report of

Charles Davis Jameson, Mem. Am. Soc. C. E.,

American Red Cross Engineer

Printed by the Commercial Press, Limited,
Shanghai
1913

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Compliments of C D Jameson

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FOREWORD

In those portions of Anhui and Kiangsu which lie north of the Huai River, the Hungtze Lake and the old bed of the Yellow River, south of the Province of Shantung and the present bed of the Yellow River, and extending east and west from the sea to the Ke River, is a section of country which has known but little rest from floods and subsequent famines for the last two thousand five hundred years.

This section is a portion of China's great alluvial plain, extending from the mountains on the West to the sea, and from Shan-hai-kwan to Hanchow. All of this plain is in process of building; no part is finished, but the least finished portion is that mentioned above, and the changes which are going on in this section form one of the most interesting examples of continent building at present in existence.

What adds to the interest of Nature's work going on here is the fact that we have the history of this section—physical, geographical and human—for the last twenty-five centuries at least. Authentic records show the changes in the river channels, the swinging north and south of the Yellow River, which during that time has passed into the sea at various points between Shanghai and Tientsin, also that at one time—some twenty centuries ago—much of the water of the Yangtsze went into the sea at Hanchow, whilst another portion flowed north into the Huai River and thence to the sea, down the now-called old bed of the Yellow River, ten centuries before the Yellow River made its last visit south.

In addition, the records of the various cities and districts give the years of flood and famine and the amount and kind of relief given to the sufferers; taxes remitted year after year, millions of ounces of silver and tons of free grain. The records also show more or less the work done to prevent the floods, or at least many of their evil effects, and in these records of the work the most noticeable fact is, that whilst enormous sums were appropriated for the building of dams, dykes, and embankments to hold and confine the water and to safeguard certain restricted areas, comparatively little or nothing was done to deepen channels or furnish means for the free and quick passage of the water to the sea. The lower reaches of the rivers were allowed to silt up until there was no adequate outlet, the embankments were raised, the unprotected areas were flooded, and eventually the embankments were broken, and floods and death and famine followed, and with this came immense appropriations for the repair of these embankments, until one can almost believe the truth of the old Chinese saying regarding the conditions which have obtained for centuries on the Yellow River, "how would we get paid for catching the tiger if he never escaped?" In modern works of this description the object is not only not to catch and confine this tiger, but to allow him to escape by a well prepared and most obvious road as quickly as possible.

During the last ten or twenty years the frightful suffering due to these floods has been brought to the notice of western nations through the foreign missionaries, and year after year hundreds of thousands or even millions of dollars have been poured into China for the relief of the sufferers, three-quarters from the United States and most of the remainder from Canada. Year after year this money from outside has gone to feed China's starving millions, and much of China's money has gone the same way, but in all these years China has not made one single effort to have the cause of these almost annually recurring floods investigated, and to ascertain whether it were not possible to lower the flood level and thus do away with the cause of the famines.

The floods have so increased in frequency and the famines in acuteness that now, over the whole area under consideration, the farmers do not average more than two crops in five years, where, if the floods were eliminated, the normal condition would be two large crops each year, and this loss is an ever increasing one. There is but small chance for the people to recuperate. Year after year they plant and the crops are lost. Then there comes a year when there is no seed to plant, then no animals with which to plough, then no ploughs or other farm implements; the house furniture follows, sold for food or used for fuel; then two families move into one hut, and the extra hut goes for fuel with which to boil weeds and the bark of trees; this gone the people steal, murder, beg, and often resort to cannibalism, and thus one of the richest agricultural sections of China is in such a condition that even robbers are becoming discouraged. No work of any kind is done to improve the rivers, the upper reaches are grown up with reeds, and plants, and the water cannot get away but spreads over the land, making swamps where once were rich fields.

Until this year (1912) the greater portion of Famine Relief has has been given free to the sufferers, with the result that to the number of the real victims of the floods have been added all the professional beggars who could work themselves into the crowd, and all persons too lazy to work but not too proud to accept charity, and who had a pull sufficient to procure a famine ticket.

This year, with the exception of old, sick or extremely young people who have no one to work for them, all who get relief have to work for it, and one man's work will feed five people. The result has been satisfactory. The number actually entitled to relief has been reduced by fully one half, and all the work done has been located and laid out so as to make it of permanent conservancy value, the work being either the building or repairing of dykes or the excavation of drainage canals and ditches and the cleaning of the existing canals.

During the summer of 1911 the National Committee of the American Red Cross and the Department of State decided that an Engineer should be sent to China to make a thorough examination of this flood and famine region, with a view to designing some scheme by means of which the flood level could be lowered, the rivers properly trained, and the swamps and shallow lakes drained and made available for agriculture. Through the American Legation in Peking this offer was conveyed to the Chinese Government, which accepted it with much pleasure, stating that it would furnish all the assistance the American Engineer might need in the way of survey parties, etc., and would also pay the field expenses of such parties and the expenses of the American Engineer from the time of the arrival in China until his preliminary examination and work were completed, the National American Red Cross paying the salary of the Engineer sent. I had the honour to be appointed by the National Committee of the American Red Cross with the approval of the Department of State for this work, and arrived in Peking on July 16th, 1911.

PART I

As the boundary lines between the different provinces—portions of which are included in the area to be studied—are in no way connected with topographical features of the country but are purely arbitrary lines, no provincial distinction can be made in the study of the various river systems, or the designing of the work to be done for the lowering of the flood level and the proper draining of the country. The whole area under consideration will simply be treated as a whole in this study, and when the actual work of construction commences it must all be treated from a national standpoint as to finances, personnel, and the methods and sequence in which the work is carried on.

The area to be studied extends from the sea coast on the east to longitude 113° on the west, and between latitudes 36° and 31° on the north. This area in a general way includes the catchment basins of all the river systems involved, and covers approximately one hundred thousand square miles. It contains portions of four provinces, Shantung, Honan, Anhui and Kiangsu, and lies between the Yangtsze River on the south and the Yellow River on the north, and within it is the Flood and Famine Region on North Anhui and North Kiangsu.

TOPOGRAPHY

Along the western and south-western borders of this area rise the mountains of Honan, the foothills of the mighty Himalayas. They push through the south-west corner in an east by north direction, following more or less the direction of the Yangtsze River, and form the divide between it and the Huaiho. As isolated hills they continue to the north-east until they join the mountains of Shantung. With the exception of this divide between the Yangtsze River and the Huai and the isolated hills, the entire area extending from the mountains of Honan to the coast is one vast alluvial plain in the making and not yet finished.

THE DIP OF THE ALLUVIAL PLAIN

The dip of this plain is as a whole to the southeast, but an examination of the Map will show that the rivers flow in all directions except west.

CLIMATE

The climate is of a mild and temperate character, the thermometer ranging from a maximum of 100° Fah. to a minimum of 20° Fah. The winter is short; the ground freezes to a depth of from two to three inches, and none of the rivers or lakes become covered with ice.

The soil is a light alluvial and of great richness, with the exception of some fifteen miles along the sea coast, where the elevation is not as yet sufficient to free it from salt.

RAINFALL

The rainy season is during June, July and August. Some rains occur during April and are of much benefit to the crops. The rainfall is ample, and when the rivers have been properly cleaned and regulated and provided with outlets, all ordinary floods will be eliminated.

DYKE REPAIRING ON THE GRAND CANAL

It is impossible to ascertain the average number of inches per normal year, as no records have been kept, but the Chinese records show that years of drought are almost unknown.

At times local rains of great magnitude occur within the famine area. In June, 1910, there was a local downpour in the region of Sze-chow, Ling-pi and Nan-Suchow, lasting some forty-two hours, during which it was estimated by the Divisional Engineer of the Tientsin-Pukow Railway that twenty-four inches of water fell.

No cleaning of rivers or opening of outlets will prevent much damage being done by such a rainfall as this. The mere force of the falling water will pound any standing crop flat to the ground and make it a dead loss. But whereas now the condition of the rivers, drainage canals, etc., is such that even a moderate amount of rain water cannot run away, but stands weeks on the ground until it soaks into sodden, swamplike soil or is evaporated, after the rivers and canals have been put into proper condition, even excessive rainfalls will be able to run off within a few hours, and leave the land in a condition for use. Abnormal storms will always and everywhere cause immediate damage by breaking down the crops, and no work of man can prevent this. The only thing possible is to so conserve the rivers and canals that the waters can pass away as quickly as possible.

AGRICULTURE AND INDUSTRIES

This entire area is strictly one of agriculture. There are no industries of more than local importance, and the existence of these is due entirely to the lack of means of transport.

The agricultural products of North Anhui and North Kiangsu are roughly as follows:—

Wheat.—The most valuable crop. This is sown in the autumn and harvested about the end of May. If there are no spring floods and the rainy season is normal this crop is very large.

Barley.—Sown in November and reaped the end of May. The amount raised is small and relatively unimportant.

Small Pea.—Sown in the wheat in the spring and often harvested with the wheat intended for home consumption ; otherwise harvested after the wheat.

Tall Millet.—Planted in April and harvested during the latter half of August.

Small Millet.—Harvested about the first half of August.

Indian Corn.—Harvested about the middle of July.

Sweet Potatoes.—Planted in May and gathered in August.

Oil Bean.—Gathered after the wheat.

Hemp.—Not very important.

Cotton.—Not very important.

Sesame, *mustard*, *opium*, *peanuts*, *tobacco*, *cabbage*, *carrots*, *radishes*, and a fair *celery*.

These constitute the staple crops, and of these wheat, oil bean and tall millet are the most important.

Up to 1908 the northern portion of the flood region in Anhui was three quarters planted with the poppy. This was prohibited without previous notice, and the people have as yet found nothing to replace it. Buckwheat has been tried, but so far with little success. All the years since the prohibition of the poppy have been famine years, and the small farmers have had no chance to adjust themselves. The opium was an exceedingly valuable crop per unit of ground required and unit of weight of the product, consequently it was the crop for the small farmer, and its prohibition has caused much suffering.

THE SURVEYOR'S HOUSEBOAT

In addition to the above-mentioned staples there is an abundance of good fruit in season, cherries, apricots, peaches, pears, grapes, small melons and water melons.

Owing to the lack of any water power and the absence of coal deposits, it is probable that when the conservancy scheme shall have been fully established and the land put into condition to bring forth its full abundance, it will be cheaper to transport the raw material, cotton, grain, beans, etc., to some central point for the production of the finished article, rather than to establish local mills and factories, but this is one of those economical problems which time alone will solve.

RIVERS AND LAKES OF THE FLOOD REGION

The main river systems of the flood region are three, viz. the Shu River, the Yi River, and the Huai River.

The Shu River has its source in the mountains of the southern portion of the province of Shantung, flows south into the province of Kiangsu, then swings to the east through nearly one hundred and eighty degrees and passes into the sea in a north by east direction near the city of Haichow.

The Yi River has its source in the mountains of the southern portion of the province of Shantung to the west of the Shu River, flows in a south-westerly direction, and empties into the Grand Canal through some five channels, the most southern one being at Yaowan in the province of Kiangsu. The catchment basin of the two rivers is about eighteen thousand square miles.

The Huai River has its source in the distant mountains of the province of Honan and flows east by north into the Hungtze Lake. It has some eighty large tributaries, and drains, or rather does not drain, a catchment basin of some seventy thousand square miles.

In the Huai River system are included not only the rivers which empty directly into the Huai River, but all of those that empty into the Hungtze Lake, as this lake is merely the backwater of the Huai due to the filling up of the regular outlet of the Huai to the sea.

LAKES

The Hungtze Lake, which is merely the backwater of the Huai River, due to its lack of suitable outlet, has an approximate area of four hundred and fifty square miles. The greater portion is less than four (?) feet in depth at normal low water, the deepest part being along the southern shore, the old channel of the Huai River when it had free access to the sea, before 1300 A.D.

DESCRIPTION OF THE THREE RIVERS

The Shu and Yi Rivers are distinctly torrential in character. Rising in the deforested mountains of Shantung, a section subject to heavy rains, the upper reaches of these rivers have a steep fall, and the lower reaches, after passing into the alluvial plain, a fall of but a few inches to the mile. In the case of the Shu its course to the sea is long and winding through this alluvial plain, a distance of 85 miles. The last twenty miles near Hai-chow are much silted up, and the consequence is that after a heavy rainfall in the deforested mountains, where there is nothing to absorb the water, it rushes down the steep incline of the upper reaches in a torrent, and upon reaching the flat country with the channel more or less silted up and in no way equal to the rapid carrying off of the large amount of water forced into it, the banks are overflowed and the country flooded, until it becomes one vast shallow lake. Eventually the water passes to the sea by innumerable and unsurveyed canals and creeks.

The whole section of Kiangsu north of the old bed of the Yellow River and east of the Grand Canal is one vast network of canals and small rivers, with their beds so little below the level of the surrounding country that only comparatively moderate rains are necessary to create floods.

The Yi River, as before mentioned, discharges into the Grand Canal. During the dry season both this river and the Shu discharge but little water and are in no sense navigable, but after rain this Yi River becomes a torrent which pours into the Canal, tearing away the western dyke (if it has been repaired since the previous floods), and flooding the country on both sides of the Canal. During the rainy season the river often rises ten or fifteen feet in twelve hours, and sweeps all before it. This torrent, loaded with silt, rushing down the Grand Canal, eats away the water face of the dykes, and eventually all the silt is deposited in the Canal and its bed raised. Consequently the Canal is to a great extent injured for navigation in the portion between Yao-wan and Sochien. The Yi River is also the principal feeder of that portion of the Canal from Yao-wan south, but this water supply is insufficient during the dry season, owing to a great extent to the fact that the water is dissipated in some five distinct channels, and during the rainy season, owing to the lack of regulating works of any description, the torrents cause much damage.

THE HUAI RIVER

The Huai River and all its tributaries as far east and including the Ke River have well-defined channels, and these channels are for the most part of sufficient capacity to handle ordinary floods.

Even during the abnormal flood of 1868 and the greater one of 1911, comparatively little damage was done west of the Ke River, and no acute famine caused.

To the north of the Huai River and the Hungtze Lake the watershed extends to near the Yellow River, and much of the actual distance to the southern dyke of the Yellow River.

To the south of the Huai River and the Hungtze Lake the watershed is narrow. The ground rises sharply to the divide between the Huai and the Yang-tsze, and the amount of water flowing north from this side is a negligible quantity in any general scheme of conservation.

THE CRITICAL SECTION OF THE HUAI RIVER

The section of the Huai River which must receive the greatest study is that portion east of the Ke River, and the continuation of the Huai River, the Hungtze Lake.

The Huai River discharges into the Hungtze Lake, and this lake has no adequate, visible, well-defined outlet through which the vast amount of water poured into it from the west may with equal rapidity pass out of it in any direction, east or south.

The dip of the country is in general to the south-east. The southern shore of the lake is rather well defined by highlands and hills. The eastern and south-eastern shore for some forty-five miles is well defined by the Ming dyke, and to the north of this, extending towards the north-west, by the magnificent embankment of the old bed of the Yellow River.

THE MING DYKE

This dyke is some 25 feet in height, 300 feet wide at the base, and some 150 feet wide at the top. It was first built during the early part of the Ming dynasty (1468) and of earth only. Although destroyed in parts by extraordinary floods, it was kept in comparatively good condition until large sections were swept away either just before or just after the commencement of the Ching-dynasty. The second emperor of the Ching dynasty, Kang-he (1662-1723) not only thoroughly rebuilt and repaired it, but added to its resistance to floods by facing the entire water side to a height of twelve feet with fine ashlar masonry laid in impure lime mortar almost equal to natural cement, each course being about sixteen inches in thickness, alternating headers and stretchers. The monumental work is in good condition to-day, and is a striking example of what the emperors of China once did for the good of the people and the country.

This dyke was built to protect the Grand Canal between Thsing Kiang-pu and the Yang-tsze River (133 miles) from the floods of the Yellow and Huai Rivers, and thus save from absolute destruction the whole section of rich and densely populated rice country east of the Grand Canal and south of the old bed of the Yellow River, known as the Hia (Low) country.

The Grand Canal

One of the most important features, both from a topographical and hydrographical standpoint in any study of the river systems of North Anhui and North Kiangsu is the Grand Canal. As shown by the map, this canal leaves the north bank of the Yang-tsze opposite the city of Chinkiang, and runs for a distance of 133 miles north to Thsing Kiang-pu. Just north of this place it crosses the old bed of the Yellow River and runs in a north-westerly direction to the borders of Shantung and beyond, eventually reaching Peking.

FAMINE RELIEF WORK

Men, women, and children, were employed building and repairing dykes, the whole of the material for such purposes being carried in baskets as here depicted.

The main object of this canal was the safe transport of tribute rice, foodstuffs and treasure from the rich lands of the south to the

Imperial Court at Peking, the passage by sea from Shanghai or other ports to Tientsin, the port of Peking, in Chinese junks, being attended with much danger from both the sea and pirates. The loss in grain, treasure and life (named in the order of their importance) was so great that the expenditure necessary to construct the canal and operate it was justifiable at the time. The present canal was completed during the Mongol dynasty, and for six hundred years afterwards, until the arrival of coast steamers and later the railways, was of great value. Even at the present date, although the through traffic to Peking has been discontinued, the canal is of immense importance as a transport route to the country through which it runs, and would well repay the cost of being put into throughly good repair and of being well maintained.

The only part of the Canal now under consideration is from the Shantung border to the Yang-tsze. The width is from 200 to 400 feet and the depth from 2 to 10 feet, depending upon the locality and the time of the year with reference to the water supply. The water is confined between artificial embankments, and in much of its length not only is the surface of the water much above the level of the adjacent country, but in many parts the bed itself of the canal is so too. This difference in elevation varies from 0 to 20 feet or more, and as the Chinese up to the present time have expended all their labour in increasing the height of the dykes and none upon lowering the canal bed, the condition becomes worse each year and the danger more imminent.

The line of the canal crosses the dip of the country at a large angle, and consequently for the whole of its length from Nan Wang Chang-tcha in Shantung where the water divides, some flowing north and some south to the Yang-tsze River, a distance of 500 miles, the canal with its high artificial dykes acts as a dam to all the natural outlets to the sea for the rivers having their sources on the west side, the most important of these being the Huai River.

The successful handling of the Grand Canal, in the maintenance of unbroken transport facilities, a minimum allowable depth, a carefully regulated water supply and the passing of the Huai River floods through it, is one of the most important and delicate problems of the proposed conservancy.

The canal acts as a great obstruction to the passing away of the havy rainfall which causes the floods, the long duration of which is caused to a great extent by the canal, and reacting are the greatest source of danger to the canal and the greatest source of damage to it, being a constant menace to its dykes, which if broken on the eastern side endanger the entire usefulness of the canal, and even if the breaks do occur much of the flood waters are of necessity obliged to find an outlet through the canal, as the canal itself cuts off all other outlets; and thus each year, during the months of June, July and August at least, the canal is required to carry away an amount of water much beyond its maximum capacity. This is a source of great danger to its dykes, and even if they do not break they are likely to be badly damaged, and a great quantity of silt is deposited which necessitates the dredging of the channel (which is never done), or the increasing of the height of the dykes (which is sometimes done).

FAMINE RELIEF WORK

As a matter of fact nothing is usually done until a serious break occurs in the dykes, much damage is done to the low (Hia) country, and valuable crops are lost with some lives, and then the repairs are made in a weak, cheap, temporary manner at a tremendous cost. With proper outlets the flood level would be lowered, the length of duration of the floods reduced, the land drained, and the danger and damage to the canal reduced to a minimum.

As has been before stated, the land on the east of the canal is much lower than that on the west, from the Yang-tsze River to

Thsing Kiang-pu, and north from Thsing Kiang-pu to about Sochien. The cause of this is that during the centuries in which the canal has been in existence it has acted as a dam to the waters coming from the north-west, and consequently the greater part of the silt brought down by these floods has deposited on the western side, gradually building up the country, the land to the east receiving only the silt carried somehow across the canal in times of excessive floods.

THE TIENTSIN-PUKOW RAILWAY EMBANKMENT

Within the last few years a new and disturbing feature has been added to the topography of North Anhui, which requires careful study with regard to the conservancy scheme. This is the embankment of the Tientsin-Pukow Railway, which, as will be seen on the Map, extends north from Peng-pu, on the Huai River, to Suchow-fu, in the province of Honan, crossing the line of the dip of the country at an angle of 60 degrees more or less. This embankment is from ten to forty feet in height, and forms a barrier to the natural flow of water in times of flood. A most careful study, of flood conditions and the amount of water to be handled was made by the Railway Engineers, and as far as could be foreseen ample openings have been made for the passage of the flood waters in such a manner as to prevent serious damage to the railway embankment, and the great floods of 1910 and 1911 passed without breaking this embankment; but whereas before its construction the flood water flowed from the north-west to the south-east in one vast sheet and the floods subsided in days, now the water having to flow south and pass through definite openings is much retarded in its subsidence, and possibly weeks are required.*

THE PRINCIPAL CAUSES OF THE FLOODS IN THE SO-CALLED FLOOD AND FAMINE REGION. THE HUAI RIVER BASIN

The entire Huai River catchment area discharges its waters into the Hungtze Lake. The bed of this lake is comparatively high, and is slowly being raised each year by the deposit of silt which it receives from the Huai and the other less important rivers coming in from the north and north-west. It may be said, however, that the percentage of silt held in suspension by the flood waters of this region is small as compared with that of such rivers as the Haiho at Tientsin, the

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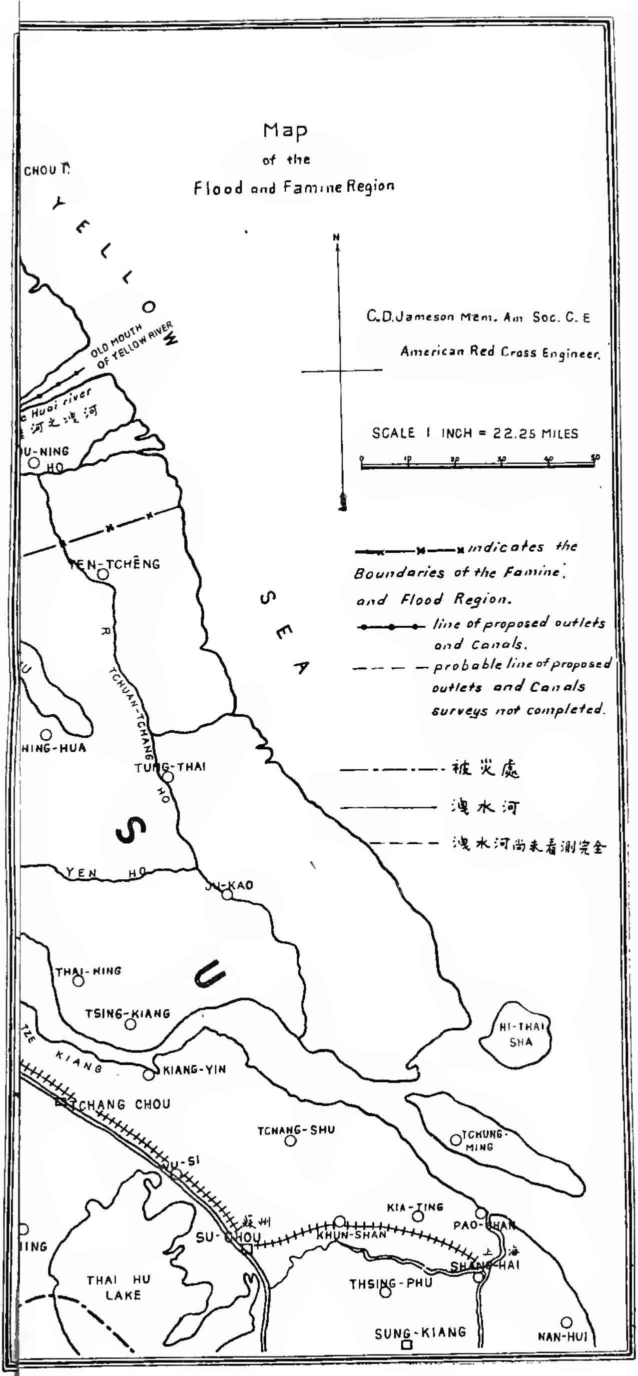
* This statement is not made as the result of personal observation, but from data given me by foreign missionaries and natives living in sections affected.—*C.D.J.*



Map
of the
Flood and Famine Region

Yellow River and the Yang-tsze, but what there is deposited in the Hungtze Lake which has no adequate outlet. The floods come from the west, north-west and north. The country has a minimum of dip and no outlet, therefore the greater part of the inundation in North Anhui is not due to the rivers over-flowing their banks, but is caused by the backwater of the Hungtze Lake and the lower reaches of the Huai, due to the fact that neither the Huai nor the Hungtze Lake have an outlet at all in proportion to the immense amount of water which is poured into them in a short period of time.

A SHORT HISTORICAL SKETCH OF BOTH THE YELLOW RIVER AND THE HUAI, AND THE CAUSES WHICH LED TO THE PRESENT EXISTING CONDITIONS

From the most ancient times of which there are reliable Chinese records, say 2000, B.C., until 1324, A.D., the Huai River had a well-defined channel and flowed freely to the sea through the Hungtze Lake by what is known to-day as the old bed of the Yellow River. The Hungtze Lake at that time covered about one quarter of its present area.

Up to 1324, A.D., the Yellow River, with one temporary exception, had its discharge to the north of the promontory of Shantung, moving its actual point of discharge up and down this coast from the borders of Shantung on the south to Tientsin on the north, at times discharging through several mouths simultaneously.

The one exception was in 1100, A.D., when it broke its southern dyke near the point now crossed by the Grand Canal, and for a short time came south more or less along the line of the present canal, spreading ruin and death in its path and discharging a portion of its flood into the Yang-tsze, breaking the canal dykes south of Thsing Kiang-pu, and spreading over the low country to the east. At the same time an immense flood in the basin of the Huai added much to the horrors of that year. This diversion of the Yellow River was, however, only of a temporary character; the break in its dyke was repaired, and it was once more confined to the north.

In 1324, however, the Yellow River having completed its continent building in North China for the time being, broke its southern dyke near Kaifengfu in Honan, and once more swept south, this time from the north-west, seeking a new channel to the sea. Several were tried during the next year or two, one by the Sha River into the Huai, then by the Ke River, then for a short time by a direct channel into the Hungtze Lake, until at last it settled down to one route, joined the Huai River just north of Thsing Kiang-pu, and with it passed into the sea in the original channel of the Huai, now known as the old bed of the Yellow River.

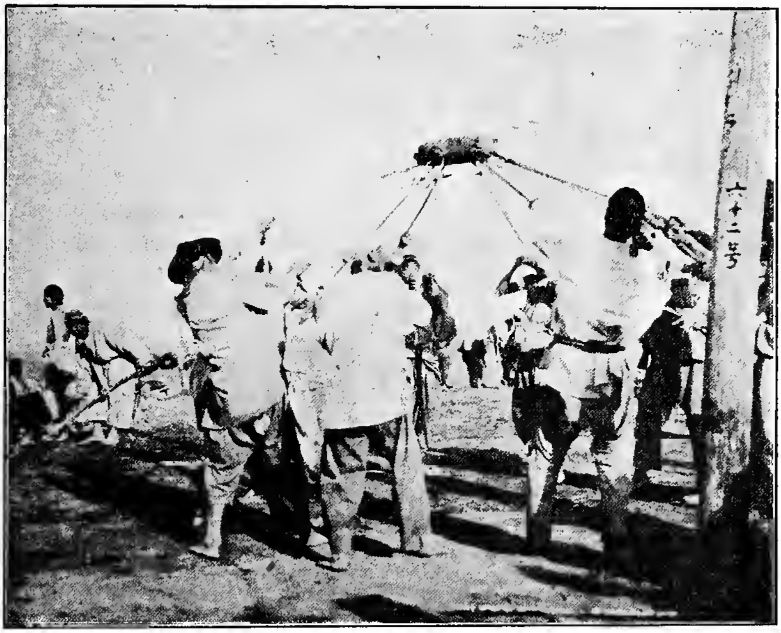
In time the immense amount of silt brought down by the Yellow River raised the bed of this channel to the height of the Hungtze Lake and more, and the floods of the Yellow River began to back up into the lake and the Huai. As the bed of the Hungtze Lake rose, its water spread over the country more and more, to the destruction of cities and towns on the northern and southern shores. Some of these cities were moved to more elevated sites, and others simply went out of commission.

The beds of the Hungtze Lake and Yellow River continued to rise, and the floods of the latter swept west as backwater in a most dangerous manner. The floods of the Huai were small compared with those of the Yellow River which must be controlled and confined. If it once forced its way into the country south of Thsing Kiang-pu it would mean the destruction of the Grand Canal from Thsing Kiang-pu south, and the utter ruin of the rich and densely populated low country south of Thsing Kiang-pu and east of the Grand Canal. Consequently the dykes of the Yellow River were greatly increased in height and thickness and faced with cut stone for some hundreds of miles, the famous Ming dyke was built, and the Huai River flowing into the Hungtze Lake was cut off from its direct outlet to the sea, and left to get out of the Hungtze Lake as best it could. The result of this is that when the heavy rains come the Huai has no way of passing them quickly on, and the water is held in the Hungtze Lake and backs up, flooding the country to the north-west. In time it passes away, partly by exfiltration in the Hungtze Lake and the swamp lands to the south-east, partly by evaporation, and partly through numerous small channels in the vicinity of Tsiang Kia-pa, leading east to the impassable barrier of the Grand Canal, and then south through the swamps and shallow lakes into the Yang-tsze. A certain amount also passes directly into the Grand Canal by the Ching River.

The amount of water to be handled is so great that often the waters of one flood cannot pass away before the arrival of the next year's flood, and the average now is that the flood areas of Anhui are inundated at least three years out of five.

In 1854 the Yellow River once more went north of Shantung, after 530 years of hard work in the south, but its enormous dyke and raised bed still present an unsurmountable barrier to the free passage of the Huai River to the sea, and the high floods still continue.

In 1854, when the Yellow River changed its course once more to the south, the Tai-ping Rebellion was in full swing, and was laying waste the Empire south of the Yang-tsze, and in many places to the north. The Imperial forces from the north were being hurried towards the south to stop the advance of the rebels. There were no railways. To meet the rebels the northern troops must come down the Grand Canal or march overland. The north dyke of the Yellow River to the west of Kaifengfu gave way, and the Yellow River poured its torrent of mud and water into this north country from the break to the sea. The Grand Canal was thus rendered useless, and from the mountains on the west to the sea was a barrier through which no troops or munitions of war could pass either way for some two years. There was much written at that time to prove that either the Taipings or Manchus cut the dyke in order to prevent the moving of troops either north or south, by land or canal. A search through these documents proves nothing either way, but certainly the dyke gave way, the country was inundated and no troops could pass, and all at a most opportune time.



DYKE BUILDING

A huge circular stone is hoisted by means of ropes by a number of men and does effective tamping work

THE WATER SUPPLY OF THE GRAND CANAL AND THE OUTLETS OF THE HUNGTZE LAKE

The main water supply of that section of the Grand Canal south of the border of Shantung and north of Thsing Kiang-pu comes from the Yi River. As has been said before, this supply is most irregular in amount. During the dry season, from November to May, the Yi River discharges but little water, not sufficient to keep the canal at a desirable depth. For a part of the time the larger cargo boats are unable to run, and even the smaller boats have to move slowly and with care, seeking the devious, narrow channel and avoiding the bars and shallows.

Much of the difficulty of navigation during the dry season is not due to the actual lack of water but to the entire neglect of any regularization of the channel, either as to uniform slope of the bottom or uniform cross section, and absolutely no work of repair or training has been attempted for years.

When the Yi River is in flood there is a superabundance of water; the channel changes from day to day, scour and deposit take place where they will, the dykes are broken or at least very much damaged, and in places the water spreads out to a thousand feet or a mile in width; the waste sluices on east side are opened, and if these are not sufficient to control the flood the "pas" are broken away and the country to the east is flooded. A "pa," as the word is used here, is a section of the dyke constructed, not of well tamped sand and clay, but of millet stalks tied in bundles, and laid at right angles to the axis of the canal. These "pa" were originally fifty or a hundred feet in length, and in the low country to the east there was, at least in theory, a suitable canal to receive the water. When the flood reaches a certain height and is still rising, in spite of the fact that all the permanent waste sluices are open, a few bundles of the millet stalks are removed from the centre of the "pa" to a depth sufficient to allow a small opening for the water which quickly does the rest. The entire temporary bank is speedily torn out, usually with some hundreds of feet of the permanent dyke on each side of it as well, the water pours into the low country, and the canal, to a certain extent, is saved. Saved, however, at the expense of the low country, as any channels which may once have existed to receive the overflow have long since silted up.

When the flood subsides and the banks and "pa" are repaired, millet stalks alone are used, being much cheaper than a well built dyke of earth, and the consequence is that some of the "pas" are now a thousand feet in length and are carried away by very moderate floods, to the great damage of the low country and to the canal itself.

The northern section of the canal may be said to finish near Yang-suan and the southern section to commence south of the lock at Thsing Kiang-pu. That section of the canal between these two points may be considered a regulating section for the regulation of the amount of water to be admitted to the southern section of the canal. Both north and south of Yang-suan are waste sluices which discharge into the Yen-ho, which in turn discharges into the sea beyond Haichow.

A COMPLETED DYKE

The Yen River, or, to give it its full Chinese name, the "River for the transport of salt," is not river but an artificial canal constructed for the transport of salt from the sea coast to Yang-suan in small boats, at which point it is transhipped into large boats, some of which are sent north up the canal, and many across the Hungtze Lake and up the Huai River, to be distributed through the entire Huai basin.

Near Matou is the so-called Thsing River, branching off from the canal and running either to or from the Hungtze Lake according as to whether the water level of the lake is lower or higher than the water level of canal. There is a dam across the Thsing River of such a height that normally it is submerged and the waters of the canal or lake pass freely over it, but in the case of extreme low water in the lake this dam is of sufficient hight to prevent the draining of the canal below a minimun level.

Beyond the opening of the Thsing River towards Thsing Kiang-pu are three so-called locks, situated about a mile apart, and at Thsing Kiang-pu is another lock. The three sluices have a clear opening of only 23 feet in width. Vertical grooves are cut in the masonry for the reception of timber balks, by means of which the water level in the pools below them may be raised some seven feet above low water, thus creating sufficient depth of slack water for the passage of cargo boats, and also when necessary for the closing of the canal to excessive overflows from the Hungtze Lake through the Thsing River when the lake is in flood. Through these locks passes all the water from the Hungtze Lake and the Huai River which finds its way into the Grand Canal, though they have openings of only 23 feet in width, and in flood time a depth of water not exceeding ten feet.

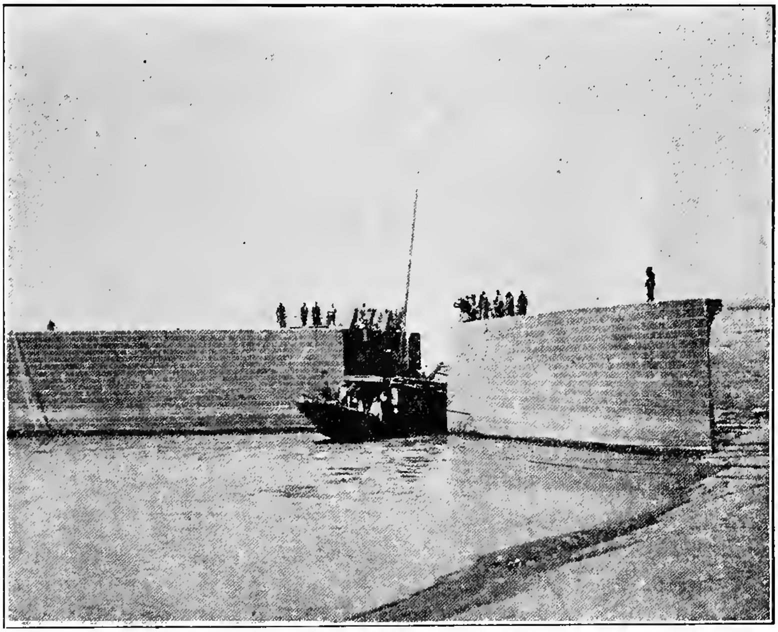
The canal from Thsing Kiang-pu south is amply provided with waste sluices in the east dyke for the passage of any excessive amount of water.

TSIANG KIA PA.

The Grand Canal cannot in any way be considered an outlet for the waters of the Huai River and the Hungtze Lake. The real outlet of the Hungtze Lake and consequently of the Huai River is through the so-called five canals from Tsiang Kia pa on the south-east side of the Hungtze Lake, running east to the marshes and lakes extending south to the Yangtsze River along the west side of the Grand Canal. These canals are some 500 feet in width and 8 feet in depth, and as defined cantls they are only some six miles long, extending from the lake east. A this point they merge into shallow lakes and marshes, only a small clear channel is maintained at Tsiang Kia pa on the lake. Four of these canals are closed by earth dams, and except during the excessive floods all the water carried off at this point passes through one of these canals. In times of excessive floods the four dams are cut successively, and as many of the canals used as are found necessary. During the dry season the water level of the lake falls to such an extent that an earth dam is built across the entrance to the canal usually kept open, to prevent the water of the lakes and marshes from draining into the lake, as it is advisable to maintain a sufficient depth in this canal to allow of the passage of boats to and from the Hungtze Lake. The passage is effected by the opening of a moveable section built into the earth dam, and pulling the boat up the incline of water from the lake by means of ropes or windlasses, or allowing it to slide down into the lake, in the same manner as boats pass the locks in the canal north of Thsing Kiang-pu.

THE FLOODS IN THE SECTION NORTH OF THE OLD BED OF THE YELLOW RIVER AND EAST OF THE GRAND CANAL.

This section extends from the sea to the dykes of the Grand Canal, and from the north dyke of the old bed of the Yellow River to the hills and mountains of southern Shantung, the Grand Canal cutting off all the waters coming from the west, with the exception of the waste waters of the Canal itself.



GRAND CANAL LOCK

This lock is one of the outlets of the Huai River at Thsiang-kiang-pu, the passage way being 23 feet wide

The river systems are the Shu and Yi, which have already been described. These both come from the north, having their sources in the mountains of southern Shantung. The Shu discharges all of its waters into this flat plain, the Yi all of the water not used to feed the Grand Canal. In addition to these two natural rivers there is the artificial canal, the Yen River, running from the point north of the old bed of the Yellow River near where it is crossed by the Grand Canal to the sea beyond Haichow in the north-east, a distance of 100 miles. The Lui-tang-ho crosses the Yen-ho at Pampu, flowing eastward to the sea. This whole section is a network of canals, crossing and recrossing in every direction. Which are artificial and which natural it is now impossible to determine. The tide from the sea comes up all of these waterways for a distance of some fifteen or eighteen miles. None of these waterways receives any care, and judging by appearances and available local information the channels are never cleaned out.

As is always the case with waterways through an alluvial country, the lower-reaches are silted up, and in many cases the bed at the lower end is higher than in the intermediate sections. This is clearly shown on the profile of the Yen-ho, where the bed near the sea is some six feet higher than the bed fifty miles further up the river. This is also shown on the profile of the Lui-tang-ho.

This silt deposit is also greatly accelerated by the action of the tide, the incoming tide having the effect of creating slack water or a slight reverse flow, giving the fresh water a chance to free itself of much of its burden of silt, while the ebb tide does not create a velocity of discharge sufficient to scour the bed, pick up this deposited silt and carry it on to the sea.

The water level is but a few feet below the natural surface, and the floods of the Shu and the local rainfall cover the whole northern section. The flood waters of the Yi escaping into the old bed of the Loma Lake, flooding that, and the flood waste from the canal to the east, with the local rainfall, completing the flooding of the region to the old bed of the Yellow River.

The greater portion of this flood is due to the fact that no defined outlets with adequate points of discharge have been provided by nature, and no artificial remedy of this apparent oversight of nature has as yet been systematically attempted by man.

This apparent oversight of nature is really no oversight at all, if we consider that the object of the work being done by these natural forces is to build up the country by means of silt deposits. The whole area which has been under examination is an unfinished country. All the natural forces are hard at work building it up to a point when it will be habitable for man without artificial restraint being put upon the natural forces. But man would not wait until nature had finished her work. He moved in and took possession several ages too soon, before there was a well drained cellar, before the floors were laid above the water level and even before the roof was finished. The result is that if man will move into an unfinished section with all its discomforts he must make the best of it, and pit his intellect against nature, tame these forces and make them work for him.

PART II

A DESCRIPTION OF THE WORK TO BE DONE TO LOWER THE FLOOD LEVEL AND DRAIN THE MARSHLANDS AND SHALLOW LAKES IN THE FLOOD AND FAMINE REGION OF THE NORTHERN PORTIONS OF THE PROVINCES OF NORTH ANHUI AND NORTH KIANGSU.

It must be understood in all that is said in this Report as to the lowering of the flood level and the practical elimination of the floods, that it applies to normal floods, such floods as occur every few years, or year after year in some cases, destroying the crops and impoverishing the people. Such floods, and consequently the damage done by them may be done away with, but at times there comes an abnormal flood or cataclysm, which sweeps before it any work of man. Such floods cannot be eliminated, but there is always the chance that such horrors may never arrive.

THE YELLOW RIVER

It may be remembered that amongst such monstrous calamaties must be reckoned the possible breaking of the southern dyke of the Yellow River and the pouring of its devastating floods of mud and water over the region under consideration. If this break should occur and the Yellow River once more come south of Shantung, the conditions governing the conservation system of this region would be radically changed, and after the immediate deluge was over there would be entirely new problems to solve.

THE SEA COAST FROM THE OLD SED OF THE YELLOW RIVER TO HAICHOW

As all the waste waters of the area north of the old bed of the Yellow River and east of the Grand Canal, together with much of the discharge of the Huai River must eventually flow into the sea at various points between the old mouth of the Yellow River and Haichow, one of the most important and one of the first pieces of work to be done is a complete survey of this section of the sea coast, the survey to be both topographical and hydrographical.

At present no charts of any value exist of this section, and none on which the soundings are correct. All sandbars, shoals, etc., shown upon existing charts of this coast are either works of the imagination, or any actual soundings recorded were taken so many years ago that nothing can be said of them beyond the fact that they are known to be incorrect at present. Of course the great reason that no accurate charts exist of this portion of the coast of China is due to the fact that there are no harbours available for sea-going vessels, and that the coasting steamers plying between existing ports such as Shanghai and the ports to the north, follow the shortest routes, and thus pass many miles to the east.

A chart should be made of this coast showing the depth of water, direction and force of any ocean currents, direction of prevailing winds, drift of the sand, rise and fall of the tides, etc., etc. This work should or might be done by the Coast Survey Department of the Chinese Maritime Customs, and they would undoubtedly undertake it if the value and necessity of the work were officially brought to the notice of the Inspector General.

The object of this survey would be to make possible the selection of the most suitable points for the discharge of the waters which now flood the back country.

This entire area is an unbroken alluvial plain, and the cost of constructing new channels to the sea or enlarging any of the existing ones would be practically the same wherever located; therefore in locating these channels the question of difference in cost may be eliminated.

The great point, and practically the only essential point upon which too much study and care cannot be expended, is the location of the points where these channels shall discharge into the sea, the best location being at those points where the configuration of the coast, the prevailing winds, the existing currents and the depth of water all combine to allow of the maximum discharge of water with a minimum cost of artificial works and a minimum cost of maintenance. These questions cannot be answered until the coast, both land and water, has been thoroughly surveyed, and all this necessary information is available.

The more water that can be discharged at these selected points the less there will remain to be taken care of by other and more expensive means, and the less will be the initial cost of the drainage and conservancy work, and the less will be the cost of maintenance.

THE SHU RIVER

This is a flood river discharging but little water during the dry season, but much in a very short time during the rainy season. No records of the actual discharge will be available until November, 1912. After leaving the mountains of Shantung and reaching the alluvial plain, this river has now one well defined channel to the sea, but many indefinite ones. The water is divided and spread out to such an extent that it has not sufficient velocity to keep a channel clean. The channels are more or less blocked by the growth of aquatic plants, which tend to retard the flow of water, spread it over the country, and year by year increase the marsh sections. Some definite channel to the sea should be selected, the shorter the better, other conditions being equal, and this channel cleaned, deepened and made of sufficiently large uniform cross section. The channel should

WORKING A LOCK

This view illustrates the method adopted to haul a Junk through a lock. Wire ropes are attached to the Junk and are wound on windlasses by the country people be excavated below the level of the country, and whether or not it should be protected by dykes is a question for further study. All side outlets or inlets should be protected by regulating sluices, so constructed as to cut off all flow of water either way when necessary, these outlets or inlets being used either to drain the adjacent land or irrigate it according as the necessity might arise.

The river need not be considered from a navigable point of view, as it is only used by small boats during a few months of the year. As the water is low in the river the greater part of the year, some inexpensive form of moveable dam may be necessary to raise the water level sufficiently for irrigation.

If flood dykes are necessary the flood channel need not be cut much, if any, below the surface of the country. The dry season channel should, however, be cut well below the surface level and kept midway between the flood dykes. In no case should it be allowed to impinge upon them and wherever a tendency is shown by the channel to work towards either dyke it should be stopped at once, and if taken at the start a river can usually be trained to hold its proper course at comparatively little expense. The great reason why the low water channel should be kept away from the dykes is that when a rise begins, and before the low water channel is overflowed, the water being confined and relatively deeper has greater velocity, and is capable of doing more damage. As the water rises and spreads out to the flood dykes the velocity decreases at the sides, and is less when the dykes are reached, increasing, however, as the depth increases; but by this time the water is above the toe of the dykes where the greatest danger of damage is, and the flood may be controlled with a minimum of danger to the dykes.

The Yi River

The problem of the Yi River is entirely different from that of the Shu.

The Yi River rises in the mountains of Shantung, and after reaching the alluvial plain of North Kiangsu divides into some five channels, all of which discharge into the Grand Canal, the most southern of these points of discharge being at the village of Yao-wan. This is a flood river similar to the Shu, but unlike the Shu it is an important feeder of the Grand Canal, and thus becomes an important factor in the maintenance of the Canal.

At present its floods are in no way controlled and do much damage each year, flooding large areas in the Pichow district, causing the loss of crops and also destroying the dykes of the canals in many places. This breaking of the dykes tends much towards lowering the water level in the canal during the dry season, much to the detriment of navigation. The bottom of the canal is not above the surface level, but when the dykes are in repair the water level is often higher than the swamp lands to the west.

The only outlet for the Yi under normal or low flood conditions is the Grand Canal, with the result that the western dyke of the canal is broken in many places, and the flood waters sweep across the canal and into the marshland beyond.

With heavy rains in the mountains of Shantung the river rises with great rapidity. In October, 1911, the river then running half full rose over twelve feet in a few hours, and flooded the village of Yao-wan. The western dyke gave way, and the country on both sides of the canal was flooded for miles, both north and south of Yao-wan, and many persons were drowned.

When the water has reached a certain height a small amount of relief is given by an overflow into the old and now normally dry bed of the Loma Lake, lying to the south and west of Yao-wan. This old lake bed is some ten miles wide east and west, and fifteen north and south. At one time it was a depression receiving the water of the Yi and discharging to the south, probably for some distance along the line of the present canal. The bed of the Loma Lake was gradually raised by silt deposits and is now dry, excepting in high floods of the Yi, when a portion of the water passes into it through a small but ill defined channel.

To do away with the flood evils of the Yi River the following work should be done:—

A well defined channel for the Yi should be cut through the Loma Lake bed and continued to the sea, probably by the enlargement of some existing channel. This channel through the lake bed should be kept as high near the side of the basin as is compatible with sufficient fall to carry away the water, in order to be of use for irrigation when necessary.

Whether the five channels by which the Yi now discharges into the Grand Canal should all be maintained or not is a question to be determined after a more detailed study and survey have been made of the existing conditions than has yet been possible. This future study of the conditions, however, will only determine what outlets are necessary for the proper irrigation of the section through which they pass, and the proper supplying of the canal with water. But whatever number of outlets are found necessary, each of these outlets should have a regulating headwork at the point where it leaves the main river. There should also be a regulating headwork across the flood canal through the Loma Lake at the point where it leaves the main river, and also one across the main river just below the opening into the flood canal.

These headworks should be worked as follows :—

During the dry season the channel to the Loma Lake should be kept closed, unless it be deemed advisable to pass a certain amount of water down it for irrigation purposes. The water passing into the Grand Canal for the purpose of maintaining its water level could pass through any or all of the outlets, the continued maintenance of which a careful study of the conditions had shown to be advisable. The maintenance of some of these outlet channels into the Grand Canal would depend upon the needs of the section for irrigation, and if but a small amount of irrigation is necessary there would be but one river channel, with the others merely irrigation ditches having small regulating sluices. But however the details may work out upon a a careful study of the conditions, the result will be that during the dry season all the available water can be utilised when and where it is most needed with a minimum of waste, and during the rainy season the sluices to the Loma Lake can be thrown open and the greater proportion of the water passed out that way, and by means of the regulating works at the inlets of the channels leading at the Grand Canal no more than the desired amount of water will reach the Grand Canal, and thus the breaking of the canal dykes and the flooding of the country will be done away with.

The Loma Lake channel should be made of ample section and cut well below the surface level. With a properly designed channel through this lake with an ample free outlet to the sea there will be but little danger of serious floods.

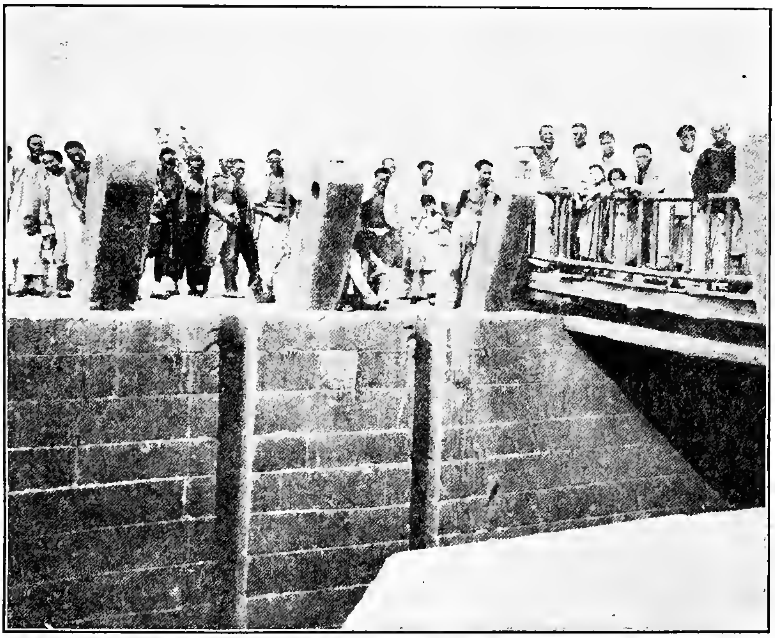
All of these channels must be well maintained, kept clean, clear of vegetation, with well defined banks and uniform cross section. The water should be confined and not permitted to spread over the country, making the land sodden, and tending each year to increase the area of the shallow lakes and marshes.

With well defined outlets to the sea, the water level of this whole section north of the old bed of the Yellow River and east of the Grand Canal can be lowered to such an extent by judicious ditching as to make possible two crops each year, this ditching to be done by and at the expense of the landowners, but entirely under the direction of the Chief Engineer of the Conservancy Board.

THE HUAI RIVER AND THE HUNGTZE LAKE

The Huai River and the Hungtze Lake will be considered as one in the general scheme of conservancy and reclamation.

The Huai River rises in the mountains of Honan and discharges into the Hungtze Lake. Its tributaries and catchment basin have been described. The two most important tributaries, the Sha and the Ke have their sources near the Yellow River, the Sha to the west of Khaifeng-fu, the capital of Honan, and the Ke to the east of it. Both of these rivers have a navigable depth of about two feet to within about thirty miles of Khaifeng-fu. From this point the land is one large marsh, traversed by many small indefinite channels. The waters of these rivers, even in extreme floods, carry but little silt, and aid but little in continent building. The Huai, itself coming from the far off mountains of Honan, contains much more silt than these rivers, but still very little when compared with the Yang-tsze and the Yellow Rivers.



A GRAND CANAL LOCK

The grooves in which the timber baulks are placed to raise the water are here well shown

DISCHARGE OF THE HUAI RIVER

On the south-west side of Huai-yuan there are two considerable mountains between which the Huai River passes. To the west of this pass is a long stretch of flat country with mountains and highlands to the south, and very gently rising land to the north. Across this stretch of some six miles in length the river has a most winding channel which about doubles its length. With any considerable rise the whole section is flooded and the wheat crop lost. Much of this flooding can be done away with by straightening and confining the channel. As it is, however, there are no hamlets in this section, the whole of it being in the hands of large landowners. Therefore the loss, when it occurs, is only that of the crops, and small farmers and small villagers are not affected.

From Huai-yuan east is that portion of the Huai River requiring the greater part of the work of improvement and regulation.

The Huai, discharging into the Hungtze Lake, which has no adequate and definite outlet, cannot dispose of its waters with the rapidity with which these waters come down from the north and west during the rainy season. The first problem, therefore, to be solved in any betterment scheme for the Hungtze Lake and the Huai River is the providing of one or more adequate outlets for the lake.

There are two possible directions in which the waters of the lake may be drained. It may discharge into the sea to the east or into the Yang-tsze River to the south. Owing to the great discharge of the Huai during the floods it has been considered wise to utilise both of the possible points of ultimate discharge.

The outlet to the east would leave the lake at or near the mouth of the Thsing River. The actual location of the ocean mouth cannot be decided upon until the hydrographical survey of the coast has been made, but under no circumstances should the channel of this new outlet be located south of the old bed of the Yellow River.

The reasons are :—

(*a*) That the country south of the old bed of the Yellow River and east of the Grand Canal is lower than the land either to the north or west, and has a lesser rate of fall to the sea.

(*b*) This entire section is densely populated and brought to a high state of cultivation, being one of the richest agricultural sections of China.

It being much lower than the country to the north and west it is always on the verge of destruction and ruin from inundation. Its defences, with the greatest care and watchfulness, are only just able to avert disaster from the many forces which now threaten it, and the opening up of a new channel through it of sufficient capacity to carry one half of the great flood discharge of the Huai, would add a tremendous menace to the future of this section.

It must be remembered, however, in designing and executing and protective work against floods, that some cataclysmic flood may come which no justifiable work of man can withstand, and if a new channel for the Huai were cut through this section and the crash came, the loss of life and property would run into millions taels and human lives; therefore almost any increased amount in the cost of the work would be justifiable to keep the proposed new channel in or north of the old bed of the Yellow River.

Even if in years to come the Yellow River shifts its channel once more to the south of Shantung by a break either near Khaifeng-fu or near where it is now crossed by the Grand Canal, there is a strong possibility that the resulting deluge would get to the sea without breaking into the low (Hia) country, the old dykes of the Yellow River and the Ming embankment serving as buttresses against which it might expend its fury in vain.

The country north of the old bed of the Yellow River and east of the Grand Canal is also a low, flat country, full of canals and watercourses. From the north it receives and will continue to receive all the flood water of the Shu River, and when the conservancy work is completed there will be a large addition to the flood waters of the Yi River. These, with the water due to its own rainfall will give it about all the water it can get rid of. Therefore, unless it is absolutely necessary, no more water should be added to this region.

For all of the above given reasons the turning of the floods of the Huai River into the low country, either to the north or to the south of the old bed of the Yellow River would be a grave error, if some other channel is available. The one available, and in many ways most desirable, is the old bed of the Yellow River itself. The gigantic dykes which would serve as flood dykes are still in existence and in fairly good condition. Between the dykes the surface level is considerably above the surface of the adjacent country, thus making possible the excavation of the entire channel for the Huai River, below the land surface. All the land between these dykes is Government property, thus eliminating the cost of purchasing new land for a right of way, and all troubles with native landowners.

The width between these old dykes is so great that even in the event of abnormal floods the water could not inundate the country.

The conditions of the old mouth of the Yellow River at the sea will not be known until the results of the hydrographical survey are available. There is, of course, the possibility that during the last fifty-eight years the ocean currents may have swept away much of the deposit of the Yellow River. However, it is not absolutely necessary to use this old mouth, as the new channel, when near the sea, can pass through the old dyke to the north and discharge into the sea at any desired point.

THE DRAINING OF THE SWAMPS AND SHALLOW LAKES

The object of this conservancy scheme is not only to lower the flood level of the Huai and the whole north country, but also to drain the thousands of acres of land now swamps and shallow lakes. These thousands of acres of exceedingly rich land are now not only useless as far as any returns are made to the people, but are worse than useless in the barrier they form to the rapid subsidence of the floods, and cause an annual increase in the acreage of swamp lands.

THE LAKES AND SWAMPS WEST OF THE GRAND CANAL AND SOUTH OF THSING KIANG-PU AND THE THIRD OUTLET FOR THE HUAI RIVER.

The lakes and swamps west of the Grand Canal and to the south of Thsing Kiang-pu, together with the second outlet for the Hungtze Lake and the Huai River will now be considered.

Other than through the small locks into the Grand Canal north of Thsing Kiang-pu, the only present outlet for the Hungtze Lake consists of the five artificial, so-called canals, all more or less well defined, starting from the south-east corner of the lake at Tsiang Kia-pa and running east through swamps to the lakes extending south three-quarters of the way to the Yang-tsze, on the west of the Grand Canal, the Pao Ying-hu, Kao-yu-hu, Shao-pu-hu, etc. An ample canal should be made from the lake at Tsiang Kia-pa towards the east, then swinging round to the south and connecting all these lakes, with an ample outlet into the Yang-tsze. The depth of the canal should of necessity be such that not only would it serve as an additional outlet for the Hungtze Lake and the Huai River, but it would drain these smaller lakes and all the contiguous swamps and marshes, thus making available for agriculture not only thousands of acres of rich land now useless, but also insuring a regularity of crops on thousands more acres by proper drainage and elimination of floods.

As these lakes, the Kao-yu-hu, etc., are on a level with the canal at its southern portion and in connection with it, their partial or complete drainage and the lowering of the water level of the section will necessitate changes in this portion of the Grand Canal itself.

THE DRAINING OF THE COUNTRY NORTH OF THE HUAI RIVER: YUNG-TCHENG, NAN-SUCHOW, LING-PI, SZE-CHOW AND SUCHOW-FU.

There are no large rivers in this section, but a sufficient number of small ones to amply drain the country if the channels were properly cleaned and regulated, and suitable outlets provided for them. No heavy and expensive work would be required here for the drainage of this section. What is needed more than anything else is the cleaning and regulating of the existing channels. They have all become more of less choked with water plants, the dykes have broken in many places, and with a small rise the water spreads over the country in shallow lakes instead of running off in a proper channel; the ground becomes sodden, seed cannot be planted nor the ground utilised in any way. The result of this is that the marsh land is increasing in area each year, overgrown with rushes and marsh vegetation. The local rainfalls, which are often very heavy, cannot run off, and must simply sink into the ground or pass away by evaporation. This process is so slow, however, that the water of one rainy season is often still on the ground when the rains of the following year arrive.

All of these channels should be thoroughly cleaned and regulated throughout their entire length and in many places straightened, the dykes rapaired, an ample outlet provided and the rivers confined to their proper channels.

After the main work of the conservancy, this secondary work should be laid out by the Engineer in charge of the section, and much of it should be carried out by the local gentry at the cost of the towns and areas benefited. All reeds should be cut on the marshes to let in the sun and wind, with the exception of sufficient reeds actually needed for fuel.

With but little heavy work this entire section of country can be well drained, the outlet being in the lower reach of the Huai somewhere east of Wu-ho, the Kui, Pa-kou and Wei Rivers being made the main arteries of the system, and possibly the channel of the Sui River may be utilised. None of the water of this region should be allowed to flow east to the Suining and Sochien districts, but should be turned south into the Hungtze Lake or the Huai River.

THE LAKES AND SWAMPS WEST OF THE GRAND CANAL AND NORTH OF THE HUNGTZE LAKE.

All of the lakes swamps west of and more or less adjunct to the Grand Canal as far north as the Shantung border should be connected with definite, clean adequate channels, and drain into the Hungtze Lake from the north.

The canals for draining the swamps and lakes of this region will not require large cross sections, as they will not be used for navigation other than by very small boats.

It must be remembered that all the canals for the drainage of this section must be cut well below the surface of the ground, that the channels must be well defined and as straight as possible, the banks properly guarded by dykes where necessary, and the channels kept clean and of uniform section, when the passage of the water itself after rain will cause sufficient erosion to keep them so.

THE SZECHOW AND WU-HO REGION.

From Szechow south flows a small river navigable by ordinary native boats for the greater part of the year. The source of this river is considerably to the north and west of Szechow, and is probably near the channel of the Pa-kou-ho north of Ling-pi. It might be desirable to utilise this small river, which on the map goes by the name of Tho-ho, as a channel for the Pa-kou-ho and the Sui-hi into the Hungtze Lake, through the lower reaches of the Huai River. The channel would require straightening and cleaning. At present this river near its outlet turns sharply to the west, runs six or seven miles, and passes into the Huai River at Wu-ho. There is a small channel near the elbow through which a certain amount of high flood water passes to the south-east and into the lower reaches of the Huai River, some ten miles west of Wu-ho. This channel could be enlarged and made the main channel for the outlet of the river. By so doing not only would the fall in the river be increased and consequently the channel made more easy of regulation, but it would afford drainage for many thousands of acres of land north, east and west of Wu-ho, which is now under water some seven months each year.

This concludes the general design for the lowering of the flood level, the drainage, reclamation and betterment of the so-called Flood and Famine Region of North Anhui and North Kiangsu, viz :—

The Shu and Yi River systems.

The Huai River system.

The Hungtze Lake

and the drainage of the swamps and shallow lakes in this region, including the lakes and marshes west of and adjacent to the Grand Canal, from the southern border of the province of Shantung to the Yang-tsze River.

The Hungtze Lake is to have an outlet towards the east, approximately along the line of the Thsing River, and down the old bed of the Yellow River to the sea, the actual point of discharge into the sea to be located after the hydrographical survey of the coast has been made.

The second outlet will be east through the Tsiang Kia-pa, then south through the lakes Pao-ying, Kao-yu, Shao-po, etc., to the Yang-tsze, the whole section under consideration, with the exception of the Shu and Yi River systems, draining into the Hungtze Lake.

Of the two new outlets of the Hungtze Lake that to the sea in the old bed of the Yellow River will be practically all new work. The outlets through Tsiang Kia-pa and the lakes to the south will be small channels connecting these large bodies of water, and the primary object of all these canals will be to carry away quickly all the flood waters of the Huai River system and the section north of the Hungtze Lake. This flood water comes from the west down the Huai River, and also from the north-west from the Khaifeng-fu region, and as far north as the present bed of the Yellow River, reaching the Huai through to the Sha and Ke Rivers or the Hungtze Lake, through the Wei, Fei, Pakou and other small rivers.

EAST AND WEST FLOOD CANALS.

In the time of abnormal floods it is found that the cause is often a heavy rainfall in the mountains of Honan and in the section north of the Huai River simultaneously, and that the water coming from the north and from the west is all poured into the critical section of the Huai at the same time, thus causing much flooding and damage. In order to obviate this to some extent, that is to prevent the flood from the west and flood and from the north reaching the Huai River east of Huai-yuan at the same time, a canal may be necessary, running more or less east or west, beginning at some point east of

Tchen, passing to the north of Ku-yang and carried east until it discharges into Hungtze Lake or the lower reaches of the Huai River. This canal would cross all the watercourses in this region, and should have sufficient fall to carry the water coming into it from the north to the Hungtze Lake.

The effect of this canal would be as follows. Supposing a flood to come from the west and from the north at the same time. Much of the water from the north would be caught in the canal, carried east, and disposed of without entering the congested portion of the Huai River, which could then accommodate the flood from the west with ease.

In building this canal proper regulating gates should be built wherever a natural watercourse is crossed, by which the water coming from the north may be passed down the natural watercourse or along the canal as may be thought best. In the case of heavy floods as much water as possible would be forced along the canal and reach the Hungtze Lake below the congested portion of the Huai River, thus leaving the Huai more free to carry the flood from the west. In the case of floods from the north only, the gates could be opened and each watercourse used to its safe maximum capacity, the balance passing along the flood canal.

With a suitable flood canal and regulating gates, much could be done to regulate the floods and lower their level.

The flood canal would be the last factor in the conservancy scheme. It should not be constructed until a careful study of the floods had been made for some years, and the effects of the outlets of the Hungtze Lake and the Huai River noted. There is, of course, a great probability that after reliable data has been obtained and the improvements in the Huai River and lake regions have been completed, this flood canal may not be found necessary. But only careful survey of the conditions and future results of the improvements can answer this question.

If the flood canal is constructed care should be taken that by means of proper sluices on its south side it would be possible, when necessary, to irrigate the country to the south.

THE WORKING OUT OF THE ABOVE SCHEME OF CONSERVANCY AND RECLAMATION.

The first thing is the hydrographical survey of the sea coast from the old mouth of the Yellow River to Haichow, to determine the most suitable points of discharge for the Shu River, the Yi River and the new outlet to the Hungtze Lake down the old bed of the Yellow River.

The Shu River.—With regard to the Shu River there appears to be no necessity for control or regulating works beyond small sluices controlling the entrance of the drainage canals. The main features of the conservancy of the Shu are to give it a clean, well defined channel to the sea, and to see that this channel and its mouth are not allowed to silt up. The channel should be excavated sufficiently below the land surface to drain the country and swamps through which it runs.

The Yi River.—With regard to the Yi River its natural outlet is by the Grand Canal to which it supplies water. The new flood channel should be cut through the Loma Lake, and thence by the best route to the sea, probably utilising and improving some already existing water course. The different branches of the Yi River to the Grand Canal, at the points were they leave the main river, should all be supplied with regulating gates in such a manner that the amount of water passing into the Grand Canal can be under proper control. This also includes gates where the flood canal branches from the main river to the Loma Lake. By this means only the requisite amount of water will enter the Grand Canal, and in the dry season the entire discharge of the Yi River will be available, while during the rainy season all excess of water will be carried away by the flood canal.

CONTROL WORKS IN THE HUNGTZE LAKE AND THE HUAI RIVER CONSERVANCY

In the final disposition of the flood waters of the Hungtze Lake and Huai River systems certain important questions must be considered as to the absolute control of this disposition. All of these waters are drained into the Hungtze Lake, and from this basin two outlets are provided, viz:—

The Canal via Tsiang Kia-pa to the Yang-tsze west of the Grand Canal.

The Canal to the east through the old bed of the Yellow River to the sea.

These two outlets will branch from the undrained portion of the Hungtze Lake, and of the two the one to the east should have the greater capacity, as during a flood it would be by far the more important.

The Yang-tsze Floods

At times heavy floods occur in the Yang-tsze basin and the Huai basin simultaneously, but fortunately this is not always nor even often the case. When the Yang-tsze is in great flood the utility of the Tsing Kia-pa canals as flood canals would be decreased, and the greater portion of the Hungtze Lake surplus would be run off through the canal to the east.

Regulating and Control Works

In years of low water in the Yang-tsze and floods in the north, the amount discharged by the two canals should be so regulated that the Yang-tsze canal would carry a safe maximum.

What remains of the Hungtze Lake after being drained to a certain level would serve, in an emergency, as a storage basin for the floods from the north and west, and from this basin lead the two outlet canals.

At the inlet to each of these two canals must be regulating sluices for the perfect control of the amount of water passing into each canal, and in connection with this regulating work there should be a suitable chamber lock for the passage of boats each way at all times.

Additional Examinations Necessary

The Ke River.—The Ke River should be examined from its mouth to its source west of Khaifeng-fu, its normal and flood discharges measured, and water gauges established at necessary points.

The Sha River and Other Tributaries of the Huai.—What has been said above applies to the Sha River and the tributaries of the Huai River to the west, and also to the Huai River itself to its source.

Swamp Lands.—The large area of swamp lands near the sources of the Ke and Sha Rivers should be examined with a view to drainage.

The Yellow River.—The most dangerous and menacing factor connected with any conservancy scheme for lowering the flood level and reclaiming the swamps and shallow lakes in North Anhui and North Kiangsu is the Yellow River on the north. If this river should break its dykes on the south and flow once more into the basin of the Huai, much of the problem of conservation would have to be re-solved. That such a break may occur is always a possibility which must be taken into account.

As soon as possible an accurate survey should be made of the Yellow River from the sea to the crossing of the Peking-Hankow Railway, and this survey should be continued up the river as rapidly as time and available money will permit, including the taking of levels, cross sections, gaugings, etc., with a view to the future regulation of this river.

The northern limit of the Huai basin is practically the southern dyke of the Yellow River, and this dyke should be most carefully examined for any leakage or seepage which may be taking place. If a break should occur in these dykes the most probable points would appear to be somewhere within the eighty mile section east and west of Khaifeng-fu, Honan, or more to the east where the Yellow River is now crossed by the Grand Canal, but of course a flagrant neglect of the dyke at any point might result in a break. The dykes should be watched with the greatest of care, and the men in charge should be held under the *strictest discipline.*

It is to be hoped that with this new era in China an exhaustive study of the Yellow River will be made, and means found to control it to a great extent, as there is no doubt that such controlling and training are possible.

With money, engineering skill and a strong permanent administration into which politics will not be allowed to enter, much could be done to eliminate the dangers due to the untamed condition of this river.

PERMANENT ENGINEERING DEPARTMENT

The most immediate need in the Huai River and Lakes Conservancy is a well organized Engineering Department.

The surveys already made by the Chinese survey students are of some value, but the organization has no definite head, the control is very loose and haphazard, and the men in control are totally lacking in all technical knowledge of the requirements of the problem of the methods necessary in the mere matter of surveys. Much time and money has been expended on relatively unimportant work, whilst the essential and urgent work has not been done at all. The office records of work done in the field are hopelessly in confusion. All these faults may be remedied with reorganization, method and discipline, and several well organised engineering parties should be put into the field at once.

So far the work of conservation has been considered by the Chinese merely from a provincial standpoint, and in the work done so far, Anhui and Kiangsu are intensely jealous of their own provincial rights, to the great detriment of the work. This conservancy work cannot in any way be considered provincial, if it is to be attended by any success. It is and must be of a purely national character, and carried, on without the slightest regard for provincial boundaries. Topography and rainfall are the ruling elements to be considered. The administration, engineering, etc., of the conservancy must deal only with the Central Government and draw its funds from the Central Government. In the question of private lands which may be needed for the work, the Conservancy Board should have the right of "Eminent Domain," the price being settled by arbitration, or if necessary the land condemned and the price settled afterwards.

In this Report it is not necessary to go into the details of the Conservancy Organization and methods of work, but a definite well disciplined organization is needed.

WEATHER BUREAU

One of the most important departments of the Conservancy Organization, and one that should be organised and put into operation as soon as possible is a Weather Bureau, with stations established at all necessary points in the entire catchment area of the river systems under consideration.

EQUIPMENT

These stations should be supplied with the following equipment:—

Wind Gauge, giving the direction and velocity of the wind.

Rain Gauge.—To measure the actual rainfall.

Wet and Dry Thermometers.—To give the degree of moisture.

Maximum and Minimum Thermometers.—To give the temperature.

Aneroid Barometers.—To give the atmospheric pressure.

Water Gauges.—To give the varying elevations of the water level in the rivers.

All these instruments could be self-recording or not, depending on the amount of money available.

The self-recording instruments are in every way preferable, as they write out the record for each minute during the twenty-four hours, and require the attention of the operator only once a day to put in new charts and wind up the weights, whilst the non-recording instruments require a reading to be taken at certain fixed times, and these readings recorded.

LOCATION OF STATIONS

The weather stations should be located at points having telegraph stations, and the records should be telegraphed to the Central Office each day, and many times a day when there are great atmospheric disturbances.

NECESSITY AND ADVANTAGES OF THE WEATHER BUREAU

At present there are no records of the rainfall in the entire region under consideration. No one knows how much rain falls during the year or at any one time, and no one knows the actual effect the rain in any one area has upon the rivers into which it flows. The only thing known is that an excessive rain fall results in floods, but this is not known until the floods arrive. With the Weather

HAICHOW CITY

A street in the centre of Haichow city, the proposed new port

Bureau stations in operation a rainfall of any importance may be foretold at least twenty-four hours in advance. When the rainfall arrives the actual amount of it can be measured and the duration recorded. With this data, given a rainfall in any part of the catchment area, say the mountains of Honan, not only will the actual amount of water which has fallen be known, but also the effect of this rainfall upon the streams and rivers through which it flows away will be known hours and days before the arrival of the water, depending upon the distance from the actual rain centre. For instance, heavy rains occur in the mountains of Honan. The duration and number of inches are wired to the Central Station. From there advice is at once telegraphed to the towns, cities or control works affected, that at such an hour the river will begin to rise, and will probably reach such-and-such a maximum elevation. Thus there is ample time to take all necessary precautions, and with the regulating works handle the floods with a minimum of damage. By means of the daily Weather Reports the farming and boating people can arrange their affairs with much more certainty and profit.

When the Conservation and Regulating Works are completed, this service will be absolutely necessary in order that the full value of the work done may be realised. Advance knowledge will be available of the coming of floods, the amount of water to be taken care of, the channels through which it will come, and the moment at which it will arrive.

This Weather Service should be extended to the Yang-tsze Valley and also to the Yellow River basin, and the more rapidly this is done the sooner will exact data be available for the regulation of these rivers. This Bureau should be worked in connection with the Weather Bureau of the Siccawei Observatory, Shanghai.

ESTIMATED COST OF WORKS

The estimated cost of the work outlined in this report will be about 35,000,000 Mexican Dollars, and the time necessary for its completion—provided no delays are occasioned by lack of money at the time when it is needed—will be from six to seven years.

As to the results which will be obtained after the completion of the work, they will be: the doing away of all but abnormal floods over an area of some 17,000 square miles, the draining of this whole area and the lowering of the flood level to such an extent that in all but abnormal years two crops will be possible each year, where, under present conditions, two crops in five years is the rule.

In addition to this improvement in land which is now supposed to be under cultivation, there will also be reclaimed some 6,000,000 Chinese *mou* of land which is now absolutely valueless, being covered with shallow lakes or swamps.

There will also be a saving of the cost of the annual famine relief, which for many years has been poured by millions and millions of dollars into this section of China.

The moral results will be the elimination of the suffering, starvation and degeneration of several millions of people, who now are fast becoming beggars and robbers ; the turning into producers of these millions who now are not only non-producers, but are becoming a menace to the country and cause of unrest and lawlessness.

In view of these obtainable results, the expenditure of this vast sum of money for the conservancy of this region is not only justifiable from a financial point of view, but is a moral necessity for the good name of China.